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13. ABSTRACT (Maximum 200 words)

My work over the granting period 5/88 - 5/90 has focused on the development of mathematical techniques to understand unstable physical processes with particular emphasis on dynamic behavior in fluids, plasmas, and multi-particles systems. The particular focus during this period has been on the development of singular perturbation techniques to study amplitude equations arising in hydrodynamic stability theory, in particular the Ginzburg-Landau equation of fluid dynamics and the Zakharov equation of plasma physics. During that time period, eight papers have been written on these and related subjects (1-8), I have presented this work at 6 invited seminars an colloquia at Universities, and have spoken at 5 conferences. See page 5 for a summary of activities. In addition, I have led a student in a Master's degree thesis entitled "Geometry and Computation of Nonlinear Schrodinger Standing Waves". This is currently being written up for publication.

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Title: Unstable Phenomena in Mechanical Systems

P.I. : Paul K. Newton, Dept. of Mathematics U. of Illinois-Urbana

Final

~~Interim~~ Progress Report on Grant No. AFOSR 88-0185

Program Manager: Dr. A. Nachman

My work over the granting period 5/88-5/90 has focused on the development of mathematical techniques to understand unstable physical processes with particular emphasis on dynamic behavior in fluids, plasmas, and multi-particle systems. The particular focus ~~during~~ this period has been on the development of singular perturbation techniques to study amplitude equations arising in hydrodynamic stability theory , in particular the Ginzburg-Landau equation of fluid dynamics and the Zakharov equation of plasma physics. During that time period, eight papers have been written on these and related subjects [1-8], I have presented this work at 6 invited seminars and colloquia at Universities, and have spoken at 5 conferences. See page 5 for a summary of activities. In addition, I have led a student in a Master's degree thesis entitled "Geometry and Computation of Nonlinear Schrodinger Standing Waves". This is currently being written up for publication.

One of the main focuses of my work during the granting period has been on the nonlinear Schrodinger limit of dispersive equations in hydrodynamic stability. I have developed two succesful approaches to these problems. The first is directed at studying branching and bifurcation processes near nonlinear plane waves. This has resulted in some very general techniques to first study the stability of these solutions [1] and then to study branching problems "near" these solutions [3,8]. Typically, there exist multi-periodic nonlinear travelling states close to the plane

waves and I have developed methods to compute them . In addition, the method is very useful in studying behavior in envelope equations with "higher order correction terms" to determine the role that these correction terms play in selecting dynamic states. This work is ongoing and has developed into a general study of singular perturbation phenomena "near" self-similar, travelling wave, and intermediate asymptotic states [9].

The second succesful approach has focused on the singular (NLS) limit of the Zakharov system governing plasma turbulence. A multi-scale perturbation technique has been developed to study wave interactions in the perturbed NLS when there no longer exist an inifinte number of conservation laws and hence radiation typically takes place. This method has been used to study soliton-sound interactions in one dimension [4,7] and is currently being extended to multi-dimensions. One of the main advantages of this method over previous methods is that it does not focus on "perturbed inverse scattering techniques" [10,11] and hence can be adapted for multi-dimensions and for a wide class of nonlinear interactions. In addition, the method can be generalized to cover various hyperbolic-dispersive interactions where there are two widely separated time scales. I am currently using the method to see if it can be helpful in making predictions on the breakdown and blow-up of bounded interacting states and the onset of turbulence in the Zakharov system [12]. A conjecture based on this method is mentioned in [7] having to do with the resonant interaction of oscillations which occur in the singular Zakharov system.

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11. Kaup D.J., A.C. Newell, "Solitons as particles, oscillators and in slowly changing media: a singular perturbation theory", Proc. Roy. Soc. , London Ser. A 361, 1978.

12. Goldman M.V., "Strong turbulence of plasma waves", Reviews of Mod. Phys., 56, No. 4, Oct. 1984.

Summary of Activities 5/88-5/90

Publications:

See references 1-8 above.

Invited Seminars and Colloquia:

1989-90:

1. Indiana University Dept. of Mathematics PDE seminar: "The Singular Zakharov System".
2. University of Wisconsin, Madison Applied Math seminar:"Particle Dynamics and Fluid Mixing"
3. Northwestern University, Applied Math Colloquium:"Particle Dynamics and Fluid Mixing".
4. R.P.I. Applied Math Colloquium:"Particle Dynamics and Fluid Mixing".

1987-88:

1. Brown University Applied Math Seminar:"The Singular Zakharov System"
2. Applied Mathematics Inc. seminar:"Some time-depenent fluids problems"

Conference Presentations:

1. International Conference on Mathematical Physics and Differential Equations, Birmingham Al., March 1990.
2. APS Annual Fluid Dynamics Meeting, NASA Ames Ca., Nov. 1989.
3. SIAM Annual Meeting, San Diego, Ca. July 1989.
4. SIAM Annual Meeting, Minneapolis, Mn, July 1988.
5. Los Alamos: Advances in Fluid Turbulence, May 1988.

Research Supervision:

Master's Degree in Computation and Applied Mathematics, U. of Illinois,
S. Watanabe, "Geometry and Computation of NLS standing Waves". 1990.